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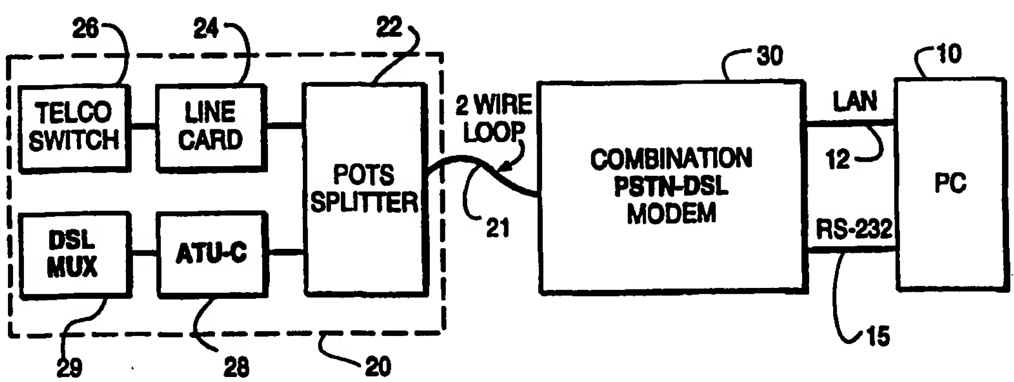

(57) Abstract

A combined xDSL and PCM modem is provided which has single digital signal processor that performs modulation and demodulation for both PCM and xDSL signals, thereby alleviating redundancy in processing equipment, reducing cost, and requiring fewer subsystems to interconnect. The digital signal processor directs modulated data onto PCM and xDSL signal channels, each of which performs conversion between digital and analog form, any required line interface processing, and respective low and high pass filtering. After filtering, the analog signals on the PCM and xDSL channels are combined and placed on the subscriber line for transmission to the telephone company central office.

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COMBINED xDSL AND PSTN MODEMS IN A SINGLE PLATORM

RELATED APPLICATION

This application claims the benefit under 35 U.S.C. § 119(e) of U.S. Patent Application Serial Number 08/946,542, filed October 7, 1997, entitled "Combined xDSL and PSTN Modem in a Single Platform" for all common subject matter disclosed therein.

BACKGROUND OF THE INVENTION

A. Field of the Invention

This invention relates to the field of data communication and more particularly to apparatus for receiving and transmitting data communications over voice-grade telephone circuits.

B. Description of Related Art

Telephone networks in most industrialized countries, as they exist today, were designed to deliver voice signals between subscribers. Voice information can be confined to the 200-3500 Hz range of frequencies and transmitted over voice-grade telephone circuits between the customer premises and the central office in analog form with acceptable quality. The telephone networks convert the voice signals to digital representation at the central office for the purpose of switching, routing and long haul delivery to the destination. The digital bandwidth available for each voice signal is 56-64 kbps (thousand bits per second). This establishes an absolute raw data carrying capacity for telephone networks. Thus, the data communication rate on the public switched telephone network (PSTN) is limited.

The information and telecommunication revolution of the 1980s and 1990s has placed tremendous pressure on the industry to create technology that achieves a higher

speed of data communications over existing infrastructure. This is particularly so in the case where one endpoint of the communication is the home or office. This demand for higher speed data communications cannot be met if the signal from the subscriber or customer premises to the central office is confined to the voice band of 200-3500 Hz. However, the art has appreciated that most subscriber loops can support signal bandwidths of between 250 kHz and 1 MHz. Fortunately, this bandwidth can support data communications at rates up to about 6 Mbps (million bits per second), hundreds of times faster than the voice band.

The current telephone network equipment is incapable of processing signals with a spectral content above 4 kHz. Consequently, the additional subscriber loop data carrying capacity presented by these higher frequencies can only be exploited if new equipment is installed at the telephone company end of the subscriber loop, as well as at the subscriber end. Technology has been developed to exploit the high frequency capacity of subscriber loops, and is known generically as "xDSL." There are several versions: ADSL (Asymmetric Digital Subscriber Loop) technology is designed to deliver a maximum data rate such as 6.0 Mbps in the network-to-subscriber (downstream) direction, and a much lower speed such as 640 kbps in the upstream direction. ADSL is intended to operate on a very high percentage of subscriber loops in industrialized countries at speeds of 384 kbps to 6 Mbps. Typical applications for ADSL are high speed Internet access and video on demand. There are several other xDSL technologies, such as VDSL, HDSL, and SDSL that are under development. These other technologies also promise high speed data transmission over the analog subscriber loops for Internet access, video on demand, and still other applications.

The device used to couple data terminal equipment to the analog phone line for xDSL transmission is referred to generically in the art as a DSL modem. Like a

conventional modem, the DSL modem performs signal modulation and demodulation, and also deals with impairments in the transmission channel such as attenuation, distortion and reflection, and performs other functions such as line probing and transmission rate adaptation. Since DSL modems operate outside of the voice band, and outside of the frequency capabilities of existing telephone company equipment, in the prior art the ADSL modems have come in pairs, one for the central office, a unit known as an ATU-C (Asymmetrical Transmission Unit - Central office), and one for the subscriber premises, known as an ATU-R (Asymmetrical Transmission Unit-Remote terminal).

A typical installation for ADSL and plain old telephone service (POTS) is illustrated in FIG. 1. In the figure, the computer system at the customer premises is represented as PC 10, and is shown connected by a local area network 12 to an ATU-R 14. ATU-R is an ADSL transmission unit that contains, among other things, a DSL modem. The PC 10 is also connected over a serial RS-232 cable 15 to an ordinary PSTN modem 16. The ATU-R unit 14 and modem 16 convert their respective data to analog form in the applicable frequency band (200-3500 Hz for the modem and 250 kHz and 1 MHz for the ATU-R). The analog signals from the ATU-R unit 14 and modem 16 are combined in a POTS splitter 18 having high and low pass filters for ADLS and POTS modem signals, respectively, and imparted onto the two wire subscriber loop 21 for transmission to the telephone company central office 20.

A second POTS splitter 22 having high and low pass filters is placed at the central office, which demultiplexes the ADSL and modem analog signals. The modem signals are sent to a line card 24 where the signals are amplified, converted to digital form, and sent to the telephone company switch 26 for long haul delivery in the switched telephone network. The ADSL signals are routed to the telephone company's

ADSL modem (ATU-C 28) where they are amplified, converted to digital form and multiplexed with other xDSL data from other users at a DSL multiplexer 29 for transmission over a high speed computer network (such as the Internet) to the destination.

Referring again to Figure 1, it will thus be appreciated that the host computer system PC 10 can enjoy a dial-up connection via the modem 16 to destinations over the public switched telephone network, and very high speed Internet or video on demand access simultaneously via the ADSL ATU-R 14. The two services coexist simultaneously with each other since they are mutually transparent. The two frequency bands are separated by high-pass and low-pass filters at each end of the subscriber loop. Moreover, the ADSL connection does not require typical POTS signaling, such as OFF-HOOK, ON-HOOK, DTMF tones, etc., and can be running continuously while a call is made over the line 21 by the PSTN modem 16.

The present inventors have appreciated that an unnecessary duplication of hardware platforms and interfaces, and resulting unnecessary expense, is presented by the typical prior art implementation of Figure 1. More specifically, the present inventors have described below a single hardware platform combining functionality for PSTN modems and xDSL modems which uses a single digital signal processor for both types of transmission formats. The resulting system provides for a number of substantial advantages: lower cost, fewer subsystems to interconnect, higher reliability, and lower power consumption. Additionally, the combined xDSL and PSTN modem presents an extremely attractive product to the retail consumer: not only are the buying a product that performs analog modem functions for POTS lines, which will be a primary feature for many consumers, they will also be assured that as xDSL ATU-C devices are rolled out in the future at the central offices of the telephone

companies, they will be already capable of xDSL communication without having to buy an xDSL modem in the future. It is predicted that a combined xDSL and PSTN modem in a single platform will be a substantial commercial success. Accordingly, a principal object of the invention is to provide a combined xDSL modem and PSTN modem in a single hardware platform.

SUMMARY OF THE INVENTION

A modem is constructed with a single digital signal processor for receiving data from a host computer system. The digital signal processor performs xDSL and PSTN modulation and demodulation of data signals to and from the host computer in the respective frequency bands of xDSL and PSTN transmission, i.e. in the voice band for PSTN modem data and above 20Hz for the xDSL data. The modem further includes an xDSL signal channel or module and a PSTN signal channel or module, each of the signal channels connected to the digital signal processor. The xDSL and PSTN signal channels also convert digital representations of xDSL and PSTN data from the DSP into analog form and supply a combined xDSL and PSTN analog signal to a telephone line interface for placement onto a subscriber telephone line. The xDSL and PSTN signal channels convert analog xDSL and PSTN data received from the telephone line into digital form and supply the digital xDSL and PSTN data to the digital signal processor.

In a preferred form, the PSTN signal channel or module comprises a CODEC (coder/decoder) connected to the digital signal processor for converting digital PSTN data into analog form and vice-versa, line interface circuitry connected to the CODEC for processing of analog PSTN signals for placement on the subscriber telephone line, and a low pass filter for removing frequency components of the analog PSTN signals outside of the voice band of the subscriber telephone line.

In a preferred embodiment, the xDSL signal channel or module comprises a CODEC connected to the digital signal processor for converting digital xDSL data into analog form, line interface circuitry connected to the CODEC for processing the analog xDSL signals into a form suitable for placement on the subscriber telephone

line, and a band pass filter for removing frequency components of the analog xDSL signals outside of the xDSL spectral band (i.e., below 20 kHz and above 1 MHz).

The modem also preferably comprises an interface for connecting the digital signal processor to the host computer system, such as a Ethernet local area network interface, RS-232 port, PCI bus, or combination thereof.

In a preferred embodiment, the combined xDSL and PSTN modem is manufactured as a stand-alone unit in a single housing containing the single digital signal processor for both xDSL and PSTN data and the PSTN and xDSL signal channels, thereby providing both modem and xDSL functionality in a single DSP computing platform. Alternatively, the modem is incorporated into a personal computer or other type of communication device, such as a network access server.

BRIEF DESCRIPTION OF THE DRAWINGS

Presently preferred embodiments of the invention will be described in conjunction with the drawings, in which like reference numerals refer to like elements in the various views, and in which:

FIG. 1 is a diagram of a prior art system in which separate PSTN modems and ATU-R units were placed at a customer premises for connecting a computer system to the subscriber line.

FIG. 2 is a diagram showing the combined PSTN modem and xDSL modem in a single platform at the customer premises.

FIG. 3 is a detailed block diagram of the combined PSTN and xDSL modems of FIG. 2.

FIG. 4 is a more detailed block diagram of the DSP platform of FIG. 3.

FIG. 5 is a perspective view of one embodiment in which the combined PSTN and xDSL modems are manufactured as an integrated unit.

FIG. 6 is a perspective view of an alternative embodiment in which the combined PSTN and xDSL modems are manufactured on a printed circuit card for installation inside a personal computer, a network access server chassis, or other type of communication device.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Figure 2 illustrates a high level view of a preferred embodiment of the present invention, in which the functionality of the PSTN modem and the xDSL modem is combined in a single hardware platform 30 at the customer premises. The combined hardware platform 30 eliminates expensive and unnecessary duplication of hardware and data interfaces by combining the xDSL modems in the same platform as an analog PSTN modem, and uses a single DSP (Digital Signal Processor) in the PSTN modem platform for both PSTN signal modulation as well as xDSL modulation. Thus, the hardware platform 30 is designed to process the 200- 4 kHz voice band signals and perform the required PSTN modem functions, such as modulation, error correction, compression, line probing etc. Additionally, the 20 kHz to 1MHz xDSL signals are processed by the same DSP hardware, which performs the Discrete Multi-Tone (DMT) modulation for ADSL developed by the American National Standards Institute (ANSI) or other applicable modulation technique. The details of DMT modulation is known in the art and therefore a description of the algorithms is omitted.

PSTN modems include various modems intended for operation over the PSTN network. Until recently most PSTN modems treated the PSTN channel as an analog band-limited channel, making adjustments for the fact that the PSTN switches actually digitized the information for transmission through the network. This was the case for e.g., ITU Recommendation V.34 modems. Recently, a new technique of utilizing the PSTN was recognized and was incorporated into ITU Recommendation V.90. In such a system, the telephone network routes digital signals directly from a digital data source to the client's local subscriber loop without any intermediary analog facilities, such that the only analog portion of the link from server to client is the client's local loop (plus the associated analog electronics at both ends of the loop). The only

CODEC in the transmission path is the one at the Telephone Company's end of the client's subscriber loop. In this configuration, a data source can convert digital data into PCM codes, and feed it to the PSTN as 8-bit bytes (octets) at the network's clock rate of 8 kHz. At the distant end, the PSTN's CODEC converts each byte to one of 255 analog voltage levels, which is sent over the client's subscriber loop and received by a subscriber device (i.e., a modem) at the client's location. This modulation technique is referred to herein as PCM modulation. As such, the PSTN modem implementing PCM modulation is referred to herein as a PCM modem, utilizing a PCM channel. Similarly, the data modulated using this format and transmitted over the PCM channel is referred to as PCM data.

The hardware platform 30 may multiplex the data from these two formats onto one local area network interface for transmission to a host computer system, or the PSTN modem signal path may have its own separate interface to a host computer system, such as via an RS-232 port to a home personal computer.

Referring now to Figure 3, a presently preferred embodiment of the combined xDSL and PSTN modem platform 30 of Figure 2 is shown in block-diagram form. The platform 30 is essentially an integrated modem comprising a single digital signal processor system 32 that receives data from a host computer system 10 via a host computer system interface 34. The digital signal processor 32 performs xDSL and PSTN modulation and demodulation of signals in the respective frequency bands of xDSL and PSTN transmission. These signal modulation and demodulation algorithms performed by the DSP 32 are the subject of standards promulgated by international standards bodies and well known in the art.

The digital signal processor 32 is connected to an xDSL signal channel or subsystem 36 and a PSTN signal channel or subsystem 38. The xDSL and PSTN

signal channels 36, 38 convert digital representations of xDSL and PSTN data from the DSP 32 into analog form, perform line interface processing as required, perform filtering, and then the signals from the two channels are combined in a multiplexer/splitter 40 and directed to a telephone line interface 42 (e.g., tip and ring terminals) for placement onto a subscriber telephone line 21. The xDSL and PSTN signal channels 36 and 38 also convert analog xDSL and PSTN data received from said telephone line 21 into digital form and supply the digital xDSL and PSTN data to the digital signal processor 32.

Still referring to FIG. 3, the PSTN signal channel 38 comprises a CODEC 44 (coder/decoder) connected to the digital signal processor 32 for converting digital PSTN data samples into analog form and incoming analog PSTN data into digital form. The signal channel further includes conventional line interface circuitry 46 connected to the CODEC 44 for any required processing of the outbound analog PSTN signals (such as signal amplification). The channel 38 also includes a low pass filter 48 for removing frequency components of the analog PSTN signals outside of the voice band of the subscriber telephone line. The CODEC 44, line interface circuitry 46 and low pass filter 48 are known in the modem art and found in the commercially available products of modem manufacturers, such as 3Com Corporation (formerly U.S. Robotics), therefore a more detailed description of these components 44, 46, 48 is omitted.

The xDSL signal channel 36 comprises a CODEC 50 connected to the digital signal processor 32 for converting outgoing digital xDSL data into analog form and vice-versa for incoming xDSL data. The signal channel 36 also includes a line interface unit 52 connected to the CODEC 50 for processing analog xDSL signals, and a high pass filter 54 for removing frequency components of the analog xDSL signals

outside of the spectral band of the xDSL signals, such as below 20 kHz and above 1MHz. The line interface unit 52 includes such features as amplifiers, line drivers and line receivers that perform noise and distortion compensation in order to meet the requirements of DMT signal conversion operations and the performance specifications of the ANSI T1.413 ETSI (Category 1-FDM) and DMT modulation standards. The details as to the xDSL CODEC 50, line interface units/drivers 52 and high pass filters 54 are considered conventional, and the reader is directed to the following reference, which is incorporated by reference herein, for further details: Alcatel MTK-20120 ASDL Modem Chipset Product Brief (September 1996), available from Alcatel Mietic, 270 E. Brokaw Rd., San Jose California 95112.

The manner at which the unitary platform 30 of Figure 3 is connected to the host computer system via computer system interface 34 may vary. A particularly preferred embodiment includes a local area network interface 60 such as an Ethernet interface unit (which is commercially available) for connecting the digital signal processor 32 to the host computer system 10. In accordance with this embodiment, the digital signal processor system may include a multiplexer (not shown) in channel 62 that multiplexes the host-bound PSTN data and the xDSL data together and supplies them to the Ethernet interface unit for transmission onto a local area network 12 for distribution to one or more host computers on the local area network 12. Alternatively, the xDSL data may be transmitted between the platform and the host computer system via the local area network interface 60, while the PSTN data is transmitted via an RS-232 port 64, a PCI bus interface 66, or other suitable means. A platform that provides RS-232, PCI bus, and local area network interfaces as shown presents a flexible approach to connecting to the host computer system, and hence is a preferred embodiment.

Referring now to Figure 4, the DSP architecture and software running in the DSP 32 in an ADSL embodiment is shown in further detail. In the illustrated embodiment, the ADSL data is transmitted from the DSP to the host computer system via the LAN interface 60 of Figure 3. Transmit and receive data bits to and from the LAN are stored in transmit and receive queues 102 and 104, respectively. The transmit data is processed by an ADSL processing software program 106, which converts the transmit data to digital ADSL transmit samples using known ADSL coding algorithms. Software module 106 also contains memory 108 shared with ADSL receive program 110 for storing transitory data during the conversion process. The ADSL transmit samples are stored in an ADSL signal transmit queue 112, and the samples are send to the CODEC 50 (Figure 3) for conversion to analog form, subsequent filtering and processing circuitry for transmission over the analog phone line to the central office. The digital ADSL samples from the ADSL transmit program 106 must replenish the transmit sample queue 112 before it runs dry. The outbound transmit queue is emptied at a constant rate due to regular periodic CODEC digital-to-analog outputs on conductor 114 from the DSP system 32 to the ADSL CODEC 50.

In the inbound ADSL signal path, inbound ADSL signal receive samples from the CODEC 50 (Figure 3) are stored in an inbound receive sample queue 116. A central controller or software overseer program 118 tells each software processing unit 106, 110 to execute the signal conversion algorithms when there are enough received analog samples in the ADSL signal receive sample queue 116. For example, when there are enough receive ADSL samples, the central controller is notified as indicated by 120 and tells the ADSL receive program 110 to execute, which turns the samples into bits. In-bound ADSL bit data is stored in the receive bit queue 104 and sent to the LAN interface 50 for transmission to the host computer system.

The processing of voice band modem data from the PCI bus or serial cable through the DSP to the modem signal path of Figure 3 is essentially the same as described above. Specifically, the DSP system 32 has transmit and receive queues 122, 124 for data to and from the host computer, voice band transmit and receive signal conversion programs 126 and 128 for converting inbound and outbound data into digital transmit and receive modem samples, and an associated memory 130 for transitory storage of data, and voice band transmit and receive queues 132 and 134 for storing transmit and receive digital modem samples. The receive queue 134 notifies the system controller program 118 when there is enough data in the queue, causing the system controller program to issue an execute command as indicated to the voice band receive program 128, which then receives the data from the queue 134, converts it using a digital modem receive algorithm and sends the data to the host-side receive bit queue 124. Outbound data from the transmit bit queue 122 is processed by the voice band transmit program 126 and sent as voice band samples to the voice band transmit sample queue 132 for transmission to the PSTN CODEC 44(see Figure 3).

Additional modem and xDSL modem functions for effective data transmission, such as rate adaptation, echo cancellation, line probing, etc., are also performed by the DSP system 32 and/or the line interface units of Figure 3, in accordance with well known techniques. Accordingly, a detailed description of these auxiliary functions is omitted for the sake of brevity.

The xDSL/PSTN platform 30 of FIG. 2 and 3 may be constructed as a stand-alone unit and sold to the public as such, in which the host computer interface(s), digital signal processor, xDSL signal channel, PSTN signal channel and subscriber line telephone line interface are installed in a single unitary housing 80, as shown in FIG. 5. This product 80 could be marketed as a combined xDSL and PSTN modem

for both home computer users and corporate customers, giving them the ability to conduct both types of data transmission simultaneously and in a mutually transparent manner in a single device. Alternatively, the host computer interface(s), digital signal processor, xDSL signal channel, PSTN signal channel and subscriber line telephone line interface could be incorporated onto a single printed circuit card 82 as suggested by FIG. 6, with the necessary bus interfaces, for installation within the chassis of a general purpose computer, network access server (such as the Total Control Enterprise Network Hub of 3Com Corporation or competing device from other manufacturers such as Ascend and Livingston Enterprises), or other type of communications equipment.

The reader is directed to the patent of Dale Walsh et al., U.S. No. 5,528,595 which is incorporated by reference herein, for a more detailed description of a network access server. In an embodiment in which the present xDSL and modem are integrated into a single platform and installed in a network access server of the Walsh et al. patent, the computing platform of one modem in the modem card of the Walsh et al. patent is augmented with the PSTN and xDSL signal channels of FIG. 3, or replaced in the manner suggested by FIG. 6, and the modem card is given an analog subscriber line interface. Persons of skill in the art will appreciate that the platform of the present invention can be adapted to other network access servers or communications equipment.

In view of the above, it will be appreciated that there has further been described a method for transmitting xDSL and PSTN data from a host computer system at a customer premises and a central office. The method comprises the steps of:

(a) receiving the xDSL and PSTN data from the host computer system at a host computer system interface 34 in a combined xDSL and PSTN modem platform 30;

(b) transmitting the xDSL and PSTN data in the combined xDSL and PSTN modem 30 from the host computer system interface 34 (e.g., along bus 62) to a digital signal processor 32;

(c) performing signal modulations with the digital signal processor 32 of the xDSL and PSTN data in different formats mutually compatible with xDSL and PSTN transmission requirements of the public switched telephone system or end user requirements;

(d) placing modulated xDSL and PSTN signals onto separate xDSL and PSTN signal channels 36 and 38 for conversion into analog form, any required line interface processing for the analog xDSL and PSTN signals, and respective high and low pass filtering; and

(e) combining the analog xDSL and PSTN signals after high and low pass filtering and placing the combined xDSL and PSTN signals onto a subscriber line 21 for transmission to the central office.

Persons of skill in the art will appreciate that various modifications may be made from the illustrated embodiments without departure from the true spirit and scope of the invention. This true spirit and scope is defined by the appended claims, to be interpreted in light of the foregoing specification.

WE CLAIM:

1. A modem comprising:

a single digital signal processor for receiving data from a host computer system, said digital signal processor for performing xDSL and PCM modulation and demodulation of signals in the respective frequency bands of xDSL and PCM transmission,

an xDSL signal channel and a PCM signal channel, each of said signal channels connected to said single digital signal processor;

said xDSL and PCM signal channels for converting digital representations of xDSL and PCM data from said DSP into analog form and imparting said analog xDSL and PCM signals onto a subscriber telephone line and for converting analog xDSL and PCM data received from said telephone line into digital form and supplying said digital xDSL and PCM data to said single digital signal processor.

2. The modem of claim 1, wherein said PCM signal channel comprises a PSTN CODEC connected to said single digital signal processor for converting incoming analog PCM data into digital form, line interface circuitry connected to said PSTN CODEC for processing said analog PCM signals, and a low pass filter for removing frequency components of said analog PCM signals outside of the voice band of said subscriber telephone line.

3. The modem of claim 1, wherein said xDSL signal channel comprises a DSL CODEC connected to said digital signal processor for converting digital xDSL data into analog form, line interface circuitry connected to said DSL CODEC for processing said analog xDSL signals, and a high pass filter for removing frequency

components of said analog xDSL signals outside of the spectral band of said xDSL signals.

4. The modem of claim 1, wherein said modem further comprises a local area network interface for connecting said single digital signal processor to said host computer system.

5. The modem of claim 1, wherein said modem is integrated into a personal computer.

6. The modem of claim 1, wherein said modem is integrated into a network access server.

7. The modem of claim 1, wherein said modem is installed in a unitary housing containing said single digital signal processor and said PCM and xDSL signal channels.

8. A combined xDSL and PCM modem in a single platform, comprising:

a host computer interface for connecting said modem to a host computer system;

a digital signal processor connected to said host computer interface and receiving digital data from said host computer system for transmission over xDSL and PCM formats to respective xDSL and PCM destinations, said digital signal processor performing signal modulation for said digital data in accordance with PCM

modulation requirements and performing signal modulation for said digital data in accordance with xDSL modulation requirements;

an xDSL signal channel for carrying modulated xDSL data from said digital signal processor to said subscriber line telephone interface, comprising a DSL CODEC for converting modulated xDSL data into analog form, a DSL line interface unit for processing said analog xDSL signals and a high pass filter for filtering out frequency components outside of the spectral band of said xDSL signals;

a PCM signal channel for carrying modulated PCM data from said digital signal processor to said subscriber line telephone interface, comprising a PSTN CODEC for converting modulated PCM data into analog form, a PSTN line interface unit for processing said analog PCM signals and a low pass filter for filtering out frequency components outside of the spectral band of said PCM signals; and

a subscriber line telephone interface receiving said analog signals from said PCM and xDSL signal channels and imparting said analog signals onto a telephone line.

9. The combined xDSL and PCM modem of claim 8, wherein said host computer interface, digital signal processor, xDSL signal channel, PCM signal channel and subscriber line telephone line interface are installed in a single unitary housing.

10. The combined xDSL and PCM modem of claim 8, wherein said host computer interface comprises an Ethernet local area network interface.

11. The combined xDSL and PCM modem of claim 8, wherein said host computer interface comprises an RS-232 port.

12. The combined xDSL and PCM modem of claim 8, wherein said combined xDSL and PCM modem is integrated into a personal computer.

13. The combined xDSL and PSTN modem of claim 8, wherein said combined xDSL and PCM modem is integrated into a network access server.

14. A method for transmitting xDSL and PCM data from a host computer system at a customer premises and a central office, comprising the steps of:

receiving said xDSL and PCM data from said host computer system at a host computer system interface in a combined xDSL and PCM modem;

transmitting said xDSL and PCM data in said combined xDSL and PCM modem from said host computer system interface to a single digital signal processor;

performing signal modulations with said single digital signal processor of said xDSL and PCM data in different formats mutually compatible with xDSL and PCM transmission requirements of the public switched telephone system or end user requirements;

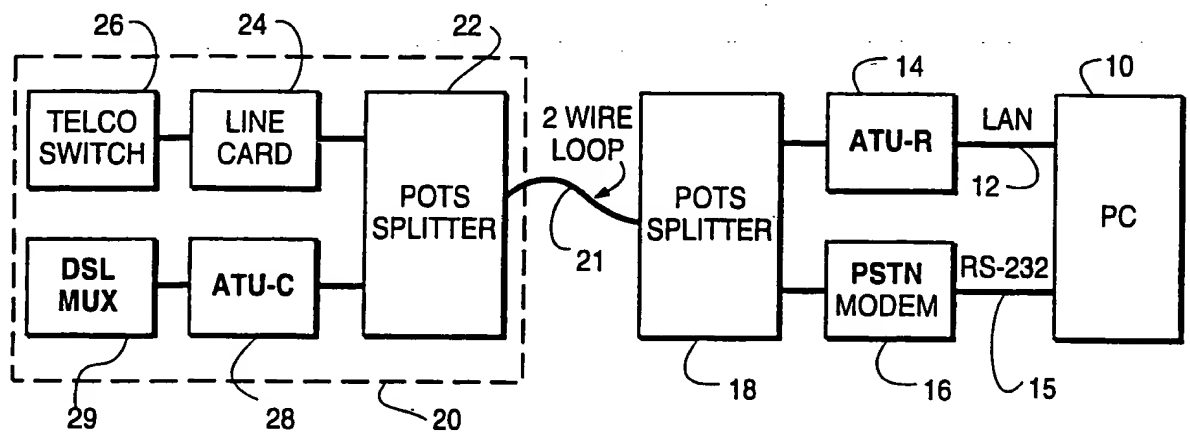
placing modulated xDSL and PCM signals onto separate xDSL and PCM signal channels for conversion into analog form, any required line interface processing for said analog xDSL and PCM signals, and respective high and low pass filtering; and

combining said analog xDSL and PCM signals and placing said combined xDSL and PCM signals onto a subscriber line for transmission to said central office.

15. The method of claim 14, wherein said modem in integrated into a network access server.

16. The method of claim 14, wherein said modem is connected to a personal computer.

FIG. 1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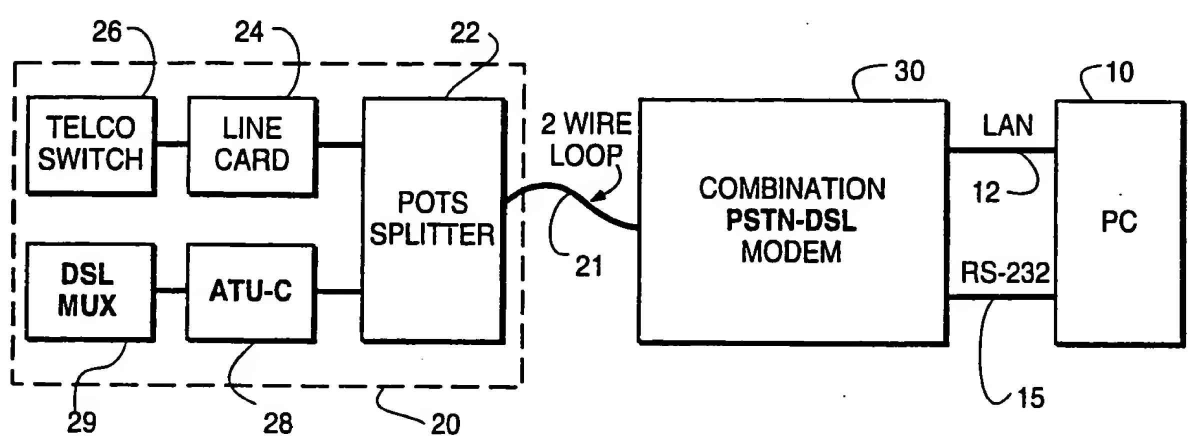
24
22
TELCO SWITCH
LINE CARD
POTS SPLITTER
DSL MUX
ATU-C
29
28
20
2 WIRE LOOP
21
POTS SPLITTER
18
14
ATU-R
PSTN MODEM
16
LAN
12
RS-232
15
10
PC

FIG. 2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24
22
TELCO SWITCH
LINE CARD
POTS SPLITTER
DSL MUX
ATU-C
29
28
20
2 WIRE LOOP
21
30
COMBINATION PSTN-DSL MODEM
LAN
12
RS-232
15
10
PC

FIG. 3

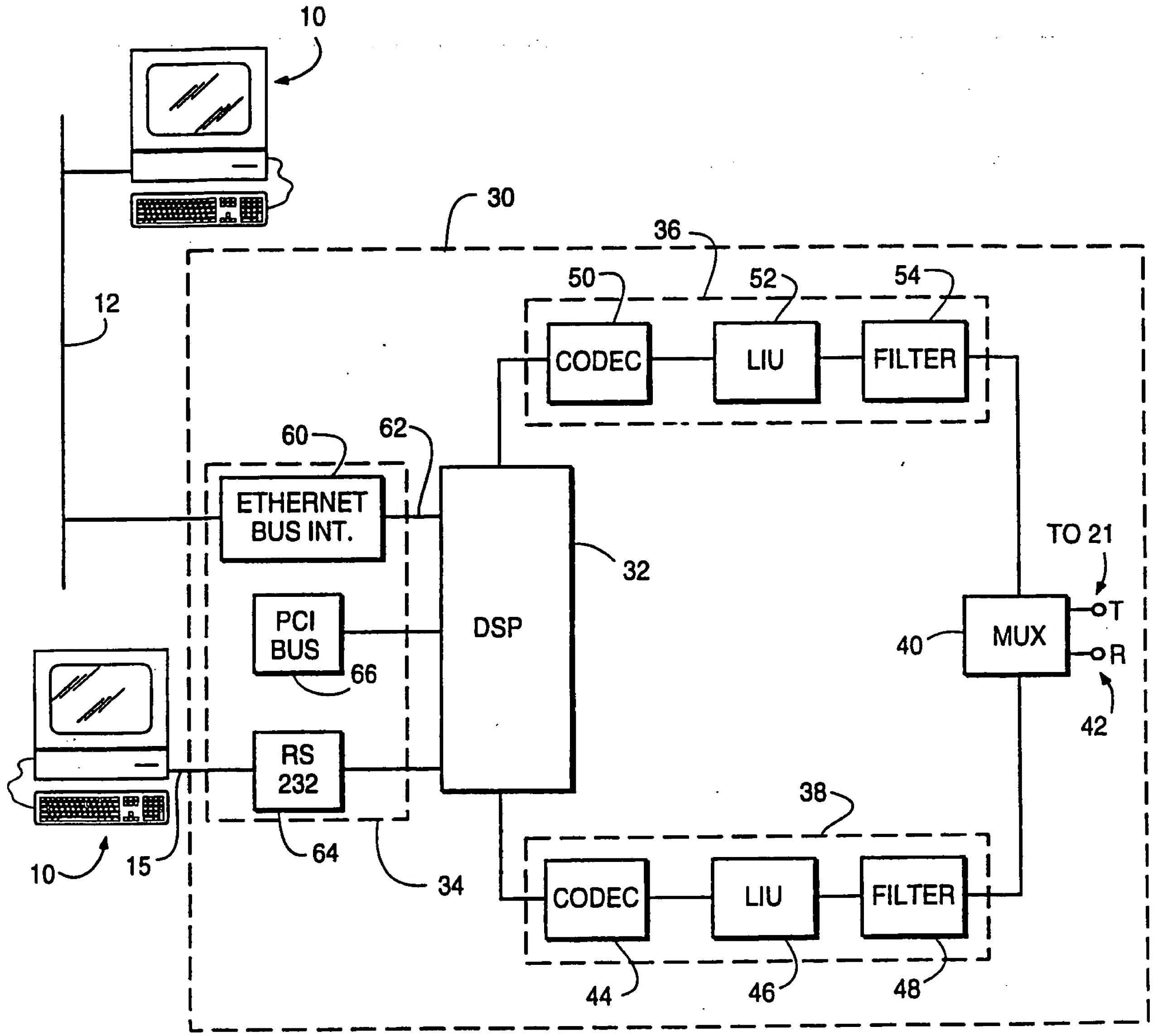
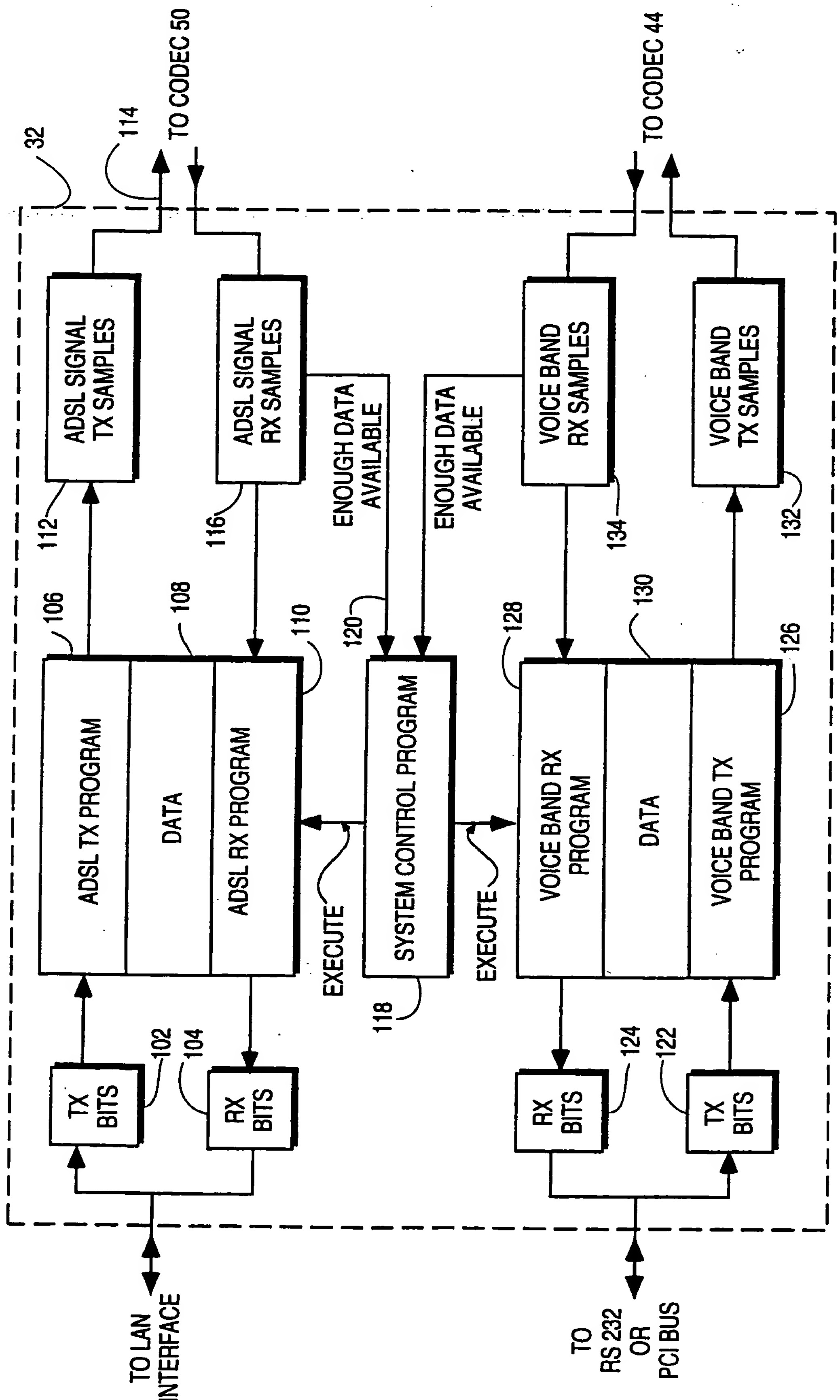
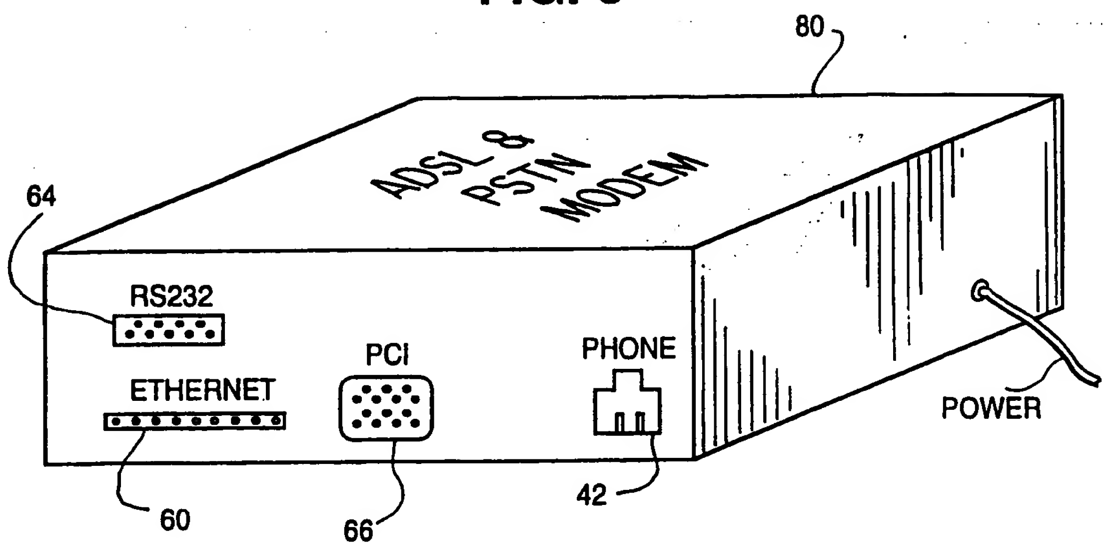

10
30
36
50
52
54
12
CODEC
LIU
FILTER
60
62
ETHERNET BUS INT.
DSP
32
TO 21
T
R
PCI BUS
66
40
MUX
42
RS 232
38
10
15
64
34
CODEC
LIU
FILTER
44
46
48

FIG. 4



TO CODEC 50
TO CODEC 44
32
114
ADSL SIGNAL TX SAMPLES
ADSL SIGNAL RX SAMPLES
VOICE BAND RX SAMPLES
VOICE BAND TX SAMPLES
ENOUGH DATA AVAILABLE
ENOUGH DATA AVAILABLE
112
116
134
132
106
108
110
120
128
130
126
ADSL TX PROGRAM
DATA
ADSL RX PROGRAM
SYSTEM CONTROL PROGRAM
VOICE BAND RX PROGRAM
DATA
VOICE BAND TX PROGRAM
EXECUTE
EXECUTE
118
TX BITS
RX BITS
RX BITS
TX BITS
102
104
124
122
TO LAN INTERFACE
TO RS 232 OR PCI BUS

FIG. 5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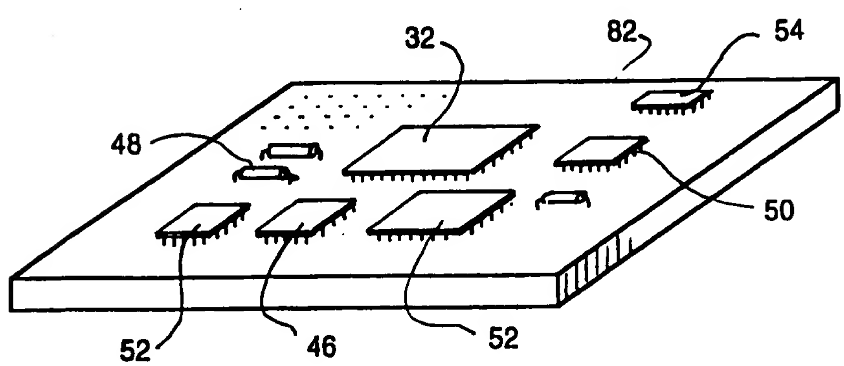
ADSL &
PSTN
MODEM
64
RS232
ETHERNET
PCI
PHONE
POWER
60
66
42

FIG. 6


32
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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 98/21112

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04M11/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	MAXWELL K: "ASYMMETRIC DIGITAL SUBSCRIBER LINE: INTERIM TECHNOLOGY FOR THE NEXT FORTY YEARS" IEEE COMMUNICATIONS MAGAZINE, vol. 34, no. 10, 1 October 1996, pages 100-106, XP000614169 see the whole document ---	1-16
Y	EP 0 772 370 A (IBM) 7 May 1997 see figure 2 see column 4, line 10 - column 10, line 13 ---	1-16
A	WO 96 27241 A (MOTOROLA INC) 6 September 1996 see figures 4-9 see page 8, line 1 - page 20, line 19 ---	1-16

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 February 1999	03/03/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Eraso Helguera, J

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 98/21112

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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A	EP 0 659 007 A (IBM) 21 June 1995 see figure 3 see column 11, line 23 - column 24, line 38 ---	1-16
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Information on patent family members

International Application No
PCT/US 98/21112

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		JP 7202945 A	04-08-1995
EP 0806852 A	12-11-1997	JP 10075279 A	17-03-1998
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